National Environmental Monitoring and Research Workshop

Draft Proceedings

S. Dillon Ripley Center, Smithsonian Institution
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Proceedings of a National Workshop on Environmental Monitoring and Research

Contents

SUMMARY
of the
National Environmental Monitoring and Research Workshop
September 25-27, 1996
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The National Science and Technology Council's Committee on Environment and Natural Resources Research convened a workshop to examine the Nation's environmental monitoring and related research. The workshop was held at the Smithsonian Institution's Ripley Center in Washington, D.C. during September 25-27, 1996. More than 160 stakeholders representing the public and private sectors participated in the workshop. The overall charge to the workshop participants was: "How can we [Federal agencies] improve our current environmental monitoring and research programs and the synthesis of that information to address policy issues related to the health of our Nation's ecosystems?"

This charge was expanded by Vice President Gore's challenge for federal agencies to work with the scientific community and other interested parties to produce a "report card" on the health of the nation's ecosystems by the year 2001.

Discussions were carried out in four groups representing four major ecosystem types: forests, coastal/marine, rangelands/croplands, and freshwater/rivers. The discussion topics included identification of policy-relevant scientific questions, variables related to ecological goods and services, and design of a national environmental monitoring and research framework. A panel of distinguished speakers from the federal and non-federal sectors explored the challenges of synthesis and prediction in the field of ecosystem health.

Three major action items were agreed to at the workshop:

1. Complete within 18 months, a draft national assessment that will iterate to the 2001 report card, and derive from existing monitoring and research.

2. Initiate a series of regional pilot projects, starting in the Mid-Atlantic Region, that takes monitoring and assessment to a more detailed level and addresses institutional issues.

3. Develop a pilot study to explore the capability of a national network of index sites, including: examining what we have now, their roles in the overall effort (cause and effect), and what would be needed to make it work, and establishing pilot sites to demonstrate and evaluate this role.

These recommendations were presented to and accepted by the CENR Environmental Monitoring Steering Committee which is directing implementation actions.

"My challenge to the Federal agencies responsible for natural resource programs and environmental quality is to work in partnership with state and local governments and non-governmental organizations. We must develop an integrated and comprehensive monitoring system out of the many separate networks that exist today." Vice President Al Gore, September 24, 1996

1. INTRODUCTION

The well-being of the United States , its people and their economy, is strongly tied to the health of its renewable resources - soil, water, air, plants, and animals. Our long-term social and economic stability depend in large measure on our ability to manage our renewable natural resources effectively and protect them from degradation and depletion. We must know the status of our resources, whether changes in this status are occurring and, if so, why and how these changes are taking place. Because the natural world is continually changing on its own, it is also vital to be able to distinguish between the causes and effects of anthropogenic and natural change.

Most environmental programs were established in response to specific resource needs and issues. While these programs are generally effective at tracking specific aspects of individual ecosystem components, they are not designed to support comprehensive, scientifically-based evaluations of the condition of the Nation's ecosystems. Our ability to interpret observed changes in the environment, make future predictions, and design effective management strategies requires an improved understanding of the structure and function of ecosystems and the interactions among their components.

The need for an integrated monitoring system was recognized by the member agencies of the Committee on Environment and Natural Resources (CENR), one of nine committees of the National Science and Technology Council (NSTC). The NSTC was created by the President in 1993 at a level equivalent to the National Security Council and Council of Economic Advisors. Its purpose is to coordinate science agencies and overcome the "stovepiping" of monitoring and research programs. CENR is composed of cabinet-level representatives of all federal agencies involved in environmental research. As the committee proceeeded with its work, it established an Ecosystems Working Group recognizing the need to examine federal programs from a perspective of ecological systems as whole entities. The Working Group recommended a comprehensive research program supporting integrated assessments at regional and national scales[1].

Recognizing that sound understanding of the environment, nationally and regionally, requires credible and defensible data, CENR launched the National Environmental Monitoring Initiative. An Environmental Monitoring Team was convened and met for several months in 1995 to develop a proposed national framework[2] for integrating the Nation's environmental monitoring and research programs. The National Environmental Monitoring and Research Workshop was designed to build upon this framework and solicit input from the scientific community to refine and revise the approaches proposed therein.

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1 *Building A Scientific Basis to Ensure the Vitality and Productivity of U.S. Ecosystems*, Ecosystem Working Group, Committee on Environment and Natural Resources, National Science and Technology Council, Executive Office of the President (December, 1995).

2 *Integrating The Nation's Environmental Monitoring and Research Networks and Programs: A Proposed Framework*, The Environmental Monitoring Team, Committee on Environment and Natural Resources, National Science and Technology Council, Executive Office of the President (draft of September, 1996; final version in January, 1997).

2. PLENARY TALKS

Plenary talks were given throughout the meeting to set the background for discussions in breakout groups. The first of these was given by Dr. John H. Gibbons, Assistant to the President for Science and Technology.

Dr. Gibbons pointed out that the United States already has the world's leading scientific infrastructure for collecting and analyzing scientific information and sharing data across agencies and with scientists everywhere. He affirmed that environmental monitoring can, and will, benefit from reinvention, and ingenuity will identify ways to use these resources more effectively across scales of space and time and with improved science and technology.

Dr. Gibbons then presented a message to the Workshop from the Vice President:

> *Environmental monitoring is the foundation for the scientific information necessary to make wise decisions key to meeting the twin goals of continued vigorous economic growth and preservation of our environmental heritage... The knowledge we gain from improved monitoring of our rivers, forests, oceans, and air is the knowledge we need to make informed decisions. The health of our ecosystems is integral to the health of our people. We are making wonderful strides in our efforts to protect the public health from environmental threats...however, it is clear that we need the best environmental observing, understanding, and forecasting capabilities that we can provide to support ecosystem management. Today's challenge is to improve those capabilities—initially across the federal agencies, and ultimately, with our public and private partners.*

In his letter to workshop participants, the Vice President called for an ecosystem "report card", a call which became a focal point of the workshop:

> *Today, I am challenging our agencies to work with the scientific community and other interested parties to produce a "report card" on the health of our nation's ecosystems by 2001. This report card should establish an environmental baseline to evaluate the status of our ecosystems. We need to know whether or not our wetlands and forests are improving, whether our timber productivity is increasing, whether our croplands are as fertile as they can be, and whether our fisheries are recovering. We need to understand if the laws we have put in place to protect the health of the environment are working.*

Setting the Tone

Secretary of the Interior Bruce Babbitt reported that he has become personally involved in the Workshop's issues through his role as chair of the Federal Geographic Data Committee (FGDC). FGDC has made slow progress in establishing common standards for data characterization (metadata). More difficult to agree on have been classification standards, but convergence is developing slowly there as well. Secretary Babbitt went on to evaluate several interagency monitoring and data-sharing efforts including those focused on federally-owned grazing laws and the mega-ecosystem of South Florida.

There is currently no single up-to-date way to assess change on the millions of acres of public lands used for grazing. The three federal agencies having lead responsibilities – Interior's Bureau of Land Management and Agriculture's Natural Resources Conservation Service and Forest Service – each has their own major range-monitoring programs based on a common system developed back in 1919. Since then, however, agency practices have diverged to the point that they are no longer compatible. The grazing land monitoring process needs to be updated based on current knowledge and consistency restored among agency methodologies.

The South Florida Ecosystem Restoration Project is a major interagency effort with considerable public and Congressional support. The Project is addressing the entire Everglades ecosystem, whose poor health stems from massive post-war urban and agricultural development. The intent is to restore surface and subsurface flows with complicated linkages, although we do not, and probably never will, know the original baseline to target. Clearly, this expansive restoration could not succeed without improved monitoring throughout the system, although EPA, USGS, NOAA, and the South Florida Water District all had different, and incompatible, approaches. These agencies have now made considerable progress toward developing a unified monitoring program, although each retains different objectives in measuring hydrological, biological, and physical parameters.

Environmental Monitoring and Research Process

Dr. Jerry Melillo, co-chair of the Workshop and nominee as the Associate Director for Environment in the President's Office of Science and Technology Policy, then stated the formal challenge to the Workshop:

> "How can we improve our current environmental monitoring and research programs (and the synthesis of data derived from them) to address policy questions related to the health of the nation's ecosystems?"

Dr. Melillo pointed out that the Council on Environmental Quality (CEQ) in 1970 reported that an effective strategy for national environmental quality requires information on status and trends. CEQ noted that we could react to problems, but could not prevent or predict them, and called for a comprehensive program of environmental monitoring. CEQ's comment at that time was that the Federal agencies collected a variety of fragmentary, incompatible data that did not provide adequate information or coverage of the national environmental condition. After 26 years, federal, state and local agencies still collect a variety of data that are fragmentary and incompatible on a national scale in type and coverage. However, we are much better off than we were: we have new tools such as remote sensing, sophisticated instrumentation for *in situ* data collection, geographic information systems (GIS), and simulation modeling techniques to aid in analysis and synthesis of data.

Dr. Melillo then presented a scheme for the overall process within which environmental monitoring and research efforts should be viewed:

- þ Identify policy goals and questions.
- þ Refine the policy goals and questions, defining sub-goals and sub-questions.
- þ Map the policy goals and questions to science questions.
- þ Select key parameters that must be measured to answer the science questions (status-and-trends questions may require different parameters than will cause-and-effect questions).
- þ Choose the best techniques for measuring the key parameters.
- þ Develop the appropriate sampling design for making the measurements.
- þ Design a data management scheme.
- þ Develop the synthesis/analysis scheme that will allow us to speak to the policy goals and questions.

This process is not new, but common acceptance of it may be useful in ensuring that basic aspects are not overlooked as we seek to improve environmental monitoring and research programs and to develop a “report card” on the health of our Nation’s ecosystems.

Environmental Assessments

The federally-prepared "Natural Resource Assessments" are as close as we come today to producing a report card on the health of the Nation's ecosystems. Of course, they are not just one report card, but over 40 separate documents, addressing bits and pieces of the overall picture we would like to have. None of these was intended to be a comprehensive report card -- all fulfill important information needs on specific topics.

To assist the workshop participants, a summary of federal natural resource assessments was developed by Robin White and provided to participants before the meeting. An overview was presented at the meeting by Dr. Robert Friedman, Vice President of the H. John Heinz III Center for Science, Economics, and the Environment and co-chair of the workshop. For this summary, assessment was defined as interpretation and evaluation of monitoring results for the purpose of answering policy-relevant questions about ecological resources. The objective of an integrated assessment is to be able to determine whether our ecosystems can provide the goods and services that society values at the level which we desire. Ultimately, we would like to know:

- þ the health of the Nation's ecological resources,
- þ the reasons why they are the way they are,
- þ the choices available for their protection and improvement,
- þ the consequences of those choices.

Present assessments by federal agencies are able to only partially answer these questions.

Examples of major federal assessments include Agriculture's Resource Conservation Act Assessment and its Forest and Rangeland Renewable Resources Planning Assessment, the interagency National Acid Precipitation Assessment Program, and EPA's Clean Water Act Biennial Assessment. The assessments all focus on fairly specific regions, resources, or stresses but over half collect information on the national or large regional scale. None of the major ecosystem categories are ignored. System functions (biogeochemical, hydrological, and geomorphic) are broadly covered. Other characteristics, such as diversity and aesthetic or existence values, are less well covered. The assessments focus heavily on status and trends of the resources or environmental goods and services they consider. Fewer, but still a considerable number, venture further, including discussion of cause and effect and even some forecasts.

Could these assessments be stapled together to provide the answers being sought? Why hasn't a comprehensive report card been produced yet? Dr. Friedman suggested two possible reasons: 1) we have not determined how to synthesize the variety of data and assessments available to us; and 2) we are not doing as well as we might in measuring appropriate parameters at the appropriate temporal and spatial scales.

Environmental Monitoring and Research Framework

The proposed Framework for National Environmental Monitoring and Research Networks and Programs was described for the workshop by Dr. Michael Ruggiero, leader of the interagency team charged by CENR to develop an integrating and coordinating mechanism. The Framework is simultaneously a monitoring framework and a strategy for assessment and synthesis of environmental data. The Framework has four main objectives: to summarize information about major federal environmental programs and related research networks; to propose a structure for integrating national and regional environmental monitoring and research across space, time, and natural resources; to provide general recommendations for integrating monitoring and research; and to propose immediate actions for agencies to implement. In general, existing networks consist of relatively few sites that take frequent measurements of a few variables or a great number of sites that monitor many variables less frequently.

The guiding principles for the Framework require it to be driven by policy needs and scientific understanding, with complete cooperation among federal, state, local, tribal, and international agencies. It should be based upon existing successful monitoring programs, and efficiently designed to ensure continuous, adaptive, interoperable and accessible coverage over the long term (perhaps 50 to 100 years). A successfully integrated program must be able to address the variety of environmental issues of current and future concern, and must answer questions needed for assessment and policy questions: Is the environment getting better or worse? Why? What can we do about it?

The conceptual paradigm for achieving the Framework's multiple goals is based upon a multi-tiered approach: the base level involves spatially continuous surveys and monitoring (remote sensing), the intermediate scale involves spatially sub-sampled surveys and monitoring, and the top level requires integrating location-specific, intensive monitoring with the broader-scale surveys. All three tiers require and have associated research (methodological) components.

There is a large gap between intensive sites and regional surveys of the first and third tiers, and multiple monitoring approaches are required. The Framework recognizes the need for "index sites"—intensive surveys of relatively small, selected areas with more variables monitored than those typically studied at extensive arrays of sites, with simultaneous research on environmental, physical, and ecological processes. Monitoring is essential to assessment of natural resources; modeling tools are used to tie monitoring over various scales of time and space to assessments at various scales. Any environmental monitoring program should be capable of five things:

- þ Determining the status of environmental values
- þ Determining changes and trends
- þ Determining causes and effects
- þ Providing early warnings of environmental perturbations
- þ Providing information to evaluate the effectiveness of environmental policies

It was noted that the design of a system to do any one of these things might be quite different from that of a system to optimize all aspects.

The National Framework recommended four actions:

(1) Integrate data and programs, resources, and media, space and time, and research and monitoring.
(2) Increase the utility of inventories and remote sensing.
(3) Enhance national and regional surveys.
(4) Establish a network of index sites.

The workshop devoted particular attention to issues of what parameters should be monitored in order to understand the health of ecosystems and the specific role that index sites should play in effectively making measurements and doing necessary research.

Summary of Current Federal Monitoring Efforts

There is a substantive national infrastructure in place for monitoring and related research. An objective of the workshop was to identify ways to better benefit from, and add value to, that infrastructure to move closer to understanding difficult ecosystem-level questions. To assist in that effort, a summary of current federal monitoring efforts was prepared, provided to participants before the workshop, and reviewed at the workshop by Dr. Donald Scavia, Director of NOAA’s Coastal Ocean Program and co-leader of CENR’s Environmental Monitoring Team.

Thirty-three major federal environmental monitoring programs, national in scope, were included in the summary. Non-federally supported programs, compliance monitoring, weather observations, and programs responsible for launching and operating environmental satellites were not included. Of these programs, the Departments of Interior and Agriculture, the Environmental Protection Agency, and the National Oceanic and Atmospheric Administration together account for 98 percent of the federal environmental monitoring budget estimated to be about $640 million annually.

The programs were divided into three levels following the proposed framework categories: "inventories and remote sensing," "national and regional surveys", and "intensive monitoring and research sites." The first category represents the remote sensing programs whose support is about $20 million per year exclusive of satellite hardware. These programs provide a capability for complete census of specific properties and are based primarily on satellite sensing and aerial photography. Examples are the LANDSAT-based programs, including the multi-agency Multi-Resolution Land Characteristics program, NOAA's Coastal Change Analysis Program, and Interior's Gap Analysis Program, and the National Wetlands Inventory. The second category includes sampling networks that are based on either deterministic or statistical survey designs. At $330 million per year, this is the largest of the three categories in terms of federal investment. Included in this category are NOAA's National Marine Fisheries Service stock surveys, USGS's National Stream Gauge Network, EPA's state, local, and national air monitoring sites, EPA's EMAP program, and the Forest Service's Forest Inventory Analysis. The third category includes networks of intensive ecosystem research and monitoring sites whose support is about $290 million annually. Among the 14 programs in this category are the Forest Service's Experimental Forests, USGS's National Water Quality Assessment program, NOAA's Coastal Ocean Program, and NSF's Long-Term Ecological Research program. Others, such as DOE's National Environmental Research Parks, should be added.

The characteristics of these programs were analyzed and presented -- the geographic distribution of environmental monitoring sites, the media focus (air, water, land, and cross-media), the discipline focus (physical, chemical, biological and cross-disciplinary), and the temporal and spatial sampling rates. The database for these programs and a capability for structured queries are now available on the World Wide Web at http:/www.epa.gov/cludygxb. The sense of this evaluation was that the current infrastructure appears to provide sufficient platforms for augmenting parameter coverage and frequency and that it can be enhanced by focusing on integrating output across time and space scales. Table 3 is a summary of the overall characteristics of our current monitoring and research networks.

TABLE 1. BENEFITS AND CHARACTERISTICS OF VARIOUS TYPES OF

MONITORING PROGRAMS

Type of Program	Benefits/Characteristics
Remote Sensing	þ biological characteristics of land cover þ continuous geographic coverage þ 5-10 year analysis frequency
Survey Programs	þ “mandatory” issue- or resource-specific information þ coverage at hundreds to thousands of sites þ weekly to annual sampling frequencies
Intensive Research Sites	þ multimedia and multidisciplinary rate-process information þ coverage at 5-50 sites or clusters of sites þ minute to monthly sampling frequencies

3. BREAKOUT SESSIONS

Workshop participants were divided among four ecosystem-based breakout groups -- forests, rangelands/croplands, fresh water, and coastal/marine. Breakout sessions, which alternated with and reported back to plenary sessions, were charged with considering several aspects of the environmental monitoring and research process outlined by Dr. Melillo in the opening session. The first breakout session was asked to consider the policy goals and science questions that need to be addressed to evaluate the health of the Nation’s ecosystems.

Our nation’s ecosystems provide us with goods and services that society values. We value a range of goods including timber from forests, crops from agroecosystems, water from rivers, and fish from oceans. We value services that ecosystems provide such as clean air and water, and stable landscapes. We also value ecosystem attributes such as the beauty of wild places that appeal to our aesthetic sense.

Many lists of these valued goods and services have been developed. These lists almost always include: 1) plant and animal species of commercial and/or recreational value; 2) a range of ecosystem functions associated with biogeochemistry, hydrology, and geomorphology; 3) various aspects of biodiversity; and 4) ecosystem attributes that have subjective value. Table 2, provided to participants before the workshop, contains a list of commonly considered goods, services, and attributes distilled from 44 federal natural resource assessments.

TABLE 2. VALUED ECOSYSTEM GOODS AND SERVICES

Productivity of commercially valued species
- timber production
- livestock production
- crop production
- fish harvesting
- shellfish production
- other commercially valued species
- natural pest control

Productivity of recreational values species
- recreational fishing
- hunting of game animals, water fowl, and other recreational valued species

Biogeochemical functions
- carbon storage
- pollutant detoxification, dilution, storage

Hydrological functions
- flood regulation
- groundwater recharge
- instream flow needs for fish and wildlife water supply
- other hydrologic functions

Geomorphological functions
- sediment retention
- wind and wave buffering
- topsoil quantity and quality

Ecosystem diversity
- genetic diversity
- species diversity
- habitat diversity

Aesthetic and existence values

open space for recreation (e.g. hiking)

cultural, heritage, and spiritual values

other aesthetic values

In the first breakout session, workshop participants were asked to augment and refine the list of ecosystem services and marketed environmental goods (as policy goals) paying special attention to 1) policy goals that need operational definition to become a useful category; and 2) emerging goals that may have become important but have not yet been articulated by policy makers.

The Forests group proposed some additions to the list of valued goods and services including: water quality and quantity, atmospheric functions (air quality and visibility, forest-climate interactions, etc.), landscape diversity, eco-tourism, and space for human habitation. The Rangelands/Croplands breakout group reworked the list of valued goods and services and came up with three broad categories: non-commercial (or non-commodity) values, services, and marketable goods and services. The group found it difficult to articulate the non-commodity values, especially the aesthetic and existence values. They extended the list of services to include biological and atmospheric services and expanded on the recreational opportunities under the marketable goods category. The Freshwater group recommended adding three categories: quality and quantity of public water supply, functional linkages to terrestrial, marine, estuarine, and atmospheric systems, and human health. In addition, they felt the table needed to address refuges for important species and transportation uses (such as waterways). The Coastal/Marine group extended the list of valued goods and services by adding aquaculture, atmospherics, and transportation. They proposed reorganizing the list by splitting pollutant/pathogen storage and disposal from the broader geochemical function in recognition of its key role in the coastal zone. They also wanted to acknowledge the very large role of tourism in the coastal environment, which they distinguished as an economic value distinct from "recreation". "Charismatic" species (endangered/threatened and popular) that were neither recreational nor commercial was missing from the list, but could fit under "Aesthetics".

Monitoring is often done to follow the status and trends of ecosystem goods and services. Both natural and anthropogenic "stresses" can change ecosystem goods and services. Table 3 contains a list of the stresses most often considered.

TABLE 3. STRESSES ON ECOSYSTEMS

"Natural" processes and factors

flood

drought
hurricanes
fire
biological population fluctuations
climatic fluctuations (e.g. El Nino)

Land use changes

construction of human settlements
conversion of ecosystems for agriculture, siviculture, etc.
water resource projects
recreational land uses

Harvesting and extraction of natural resources

forestry
agriculture
commercial and sport fishing
aquaculture
wildlife hunting and trapping
extraction of fossil fuels, minerals, etc.
surface and groundwater withdrawal

Releases of substances and organisms

air pollutants (SO_2, NO_x, VOC, air toxics, etc.)
global atmospheric pollutants (greenhouse gases, etc.)
water pollutants (nutrients, BOD, pesticides, etc.)
land disposal of wastes
exotic species and native “pest” species

Information on status and trends is frequently combined with information derived from monitoring of natural and anthropogenic stresses on ecosystems in an attempt to attribute causes to observed changes in ecosystem goods and services. The science questions related to environmental monitoring generally derive from efforts to establish cause and effect relationships and build predictive capabilities.

The breakout groups considered the usefulness of this view in relating ecosystem goods and services to key scientific questions. The Rangelands/Croplands group used livestock production as an test example. Forests group preferred to replace the label “Stressors” with “Change Agents” because the former implied that the agents were outside the system.

Key Parameters and Measurements

The breakout groups were also asked to identify the key scientific parameters and questions that will allow: 1) tracking the status and trends of ecosystem services and marketed environmental goods; and 2) understanding the causes of changes in these services and goods and thus predicting consequences of change. The following tables summarize the results of the breakout group discussions on key parameters for forest, rangeland and cropland, freshwater, and coastal/marine systems.

Forest Ecosystems

The Forest group undertook their charge to identify the key scientific parameters and questions that will allow policymakers to track status and trends of changes in ecosystems. The group adopted the tactic of first going through the list of items in Table 2 (modified as noted above) and identifying key parameters and science questions that would be useful for monitoring status and trends.

TABLE 4. KEY PARAMETERS FOR TRACKING STATUS AND TRENDS IN FOREST ECOSYSTEMS

Goods and Services	Key Parameters and Considerations	Scientific Questions
Timber production	þ Biomass þ Stand inventory þ Growth and change in growth þ Site index þ Forest area, age class and spatial distribution, cover type þ Yield and removal þ Availability þ Reserved and unreserved acreage	Are rates and spatial distributions of biomass production changing? Are biological tradeoffs occurring?
Other commercially valued species	þ Biomass/standing crop, age and spatial distribution þ Inventories of species þ Hierarchical approach to monitoring from genes to landscapes þ Yields þ Most of the items listed under Timber Production would also apply here.	
Status of natural pests and fire	þ Understory and litter biomass fuel load þ Index of fire and pest susceptibility þ Trends in pest species	What trends are their in fuel loads and losses to pests?
Hunting of game animals	þ Annual harvests þ Population properties þ Browse production þ Habitat area þ Herd health (morbidity and mortality)	What are the trends in distribution and abundance of recreationally valued species?
Biochemical functions	þ pH þ Tree and plant species þ Total carbon þ Changes in areas and stand age þ Carbon dioxide fluxes þ Plant and soil C, and other nutrients pools over space and time þ Input/output budgets and cycling of nutrients and trace gases at fewer sites þ Site index	How are pools of C and nutritionally important elements changing over time and space?

Hydrological functions	þ Hydrography þ Weather records þ Land cover and use þ Presence of dams/impoundments þ Forest wetlands þ Pulp and paper production effluents þ Sediment loads þ Chemical composition, including total nutrients and pesticides and herbicides in stream water þ Application rates of pesticides and herbicides þ Water temperature	How do trends change over time?
Atmospheric functions	þ Ambient air concentrations þ Input/output of trace gases (deposition) þ Ozone concentrations in time and space þ Albedo þ Deposition and production (input/output) of particulates, water, etc.	
Geomorphological functions	þ Stream turbidity þ Erosion rates þ Reservoir siltation	
Ecosystem diversity	þ Numbers of species by functional group (*i.e.*, native, non-native, invasive, endemic) þ Population properties of key species þ Composition, structure, function þ Spatial distribution of different community and cover types (patch sizes, fragmentation, conversion) þ Genetic diversity of key species þ Forests converted to other uses þ Changes in boundaries between ecosystem types	
Aesthetic/existence values	þ Recreational Opportunity Spectrum (ROS) þ Land use map and number of visitor days þ Area in wilderness, park status þ Willingness to pay to set up protection programs, etc. þ Indices of sites with cultural heritage and spiritual value	

Cross-cutting issues		þ Forest management practices affect livestock, crop, fish production þ Status of riparian habitat þ Some products, *e.g.*, salmon, cross-cut all ecosystems (forests, marine, aquatic)

The group reviewed the list of descriptors and variables proposed for vegetation and soil in the Framework document. They identified which of the parameters could be measured at intensive sites and which could be measured nationally at extensive sites. In a similar fashion the group considered measurements related to biodiversity.

TABLE 5. DESCRIPTORS/ VARIABLES TO MEASURE IN VEGETATION AND SOIL

Intensive Sites	
Vegetation	Soil
þ Leaf % N, P	þ Water retention curve
þ Leaf % lignin	þ Infiltration parameters
þ Leaf C-13/C-12	þ Soil moisture
þ Leaf N-15/N-14	þ Available N
þ Litter fall	þ Denitrification rate
þ Flowering	þ C-13/C-12 in SOM
þ Leaf budbreak	þ N-15/N-14 in SOM
þ Above-ground NPP	þ % water stable aggregates
þ Below-ground NPP	þ Total N (by aggregate size)
	þ Total C (by aggregate size)
	þ Soil temperature
	þ Exchangeable acidity
	þ Toxic contaminants
Extensive Sites	
Vegetation	Soil
þ % cover by species	þ % organic matter
þ Demography by species	þ Water holding capacity
þ Size (DBH, height)	þ Litter
þ Leaf Area Index	þ Total N
þ Establishment by species	þ Major cations
þ Phenological stages	þ Major anions
þ Necromass	þ pH in water
þ Leaf and stem lesions	þ CEC
þ Leaf wilt	
þ Chlorosis	

TABLE 6. DESCRIPTORS AND VARIABLES TO MEASURE FOR BIODIVERSITY

Intensive Sites	Extensive Sites
þ Demographic studies	þ Species abundance (plants)
þ Importance of species diversity to ecosystem function	þ Conservation status (extinction potential, trends, abundance in population at species to ecosystem levels)
þ Develop comprehensive species list	þ Habitat-derived metrics from plot and remote sensing
þ Controlling factors	þ Species distribution of common species
þ Genetic diversity	þ Exotics
þ Natural variability	
þ Habitat models	

Rangeland and Cropland

The discussion of the group focused on preparing a short list of system-level parameters or indicators that could be used to determine the capability of rangeland and cropland to sustain goods and services. Those parameters included the following:

Net primary production monitored remotely to provide repetitive coverage of spatial and temporal patterns;

Soil organic matter;

Species diversity including presence and abundance, invasive species, and pest and disease impacts on plants and animals;

Climate data (temporal and spatial) as needed for interpreting other parameters;

Surface/subsurface hydrology including quantity and quality;

Land cover/management (land use change);

Landscape patterns and metrics, possibly as a subset to land cover/management;

Soil erosion/sediment production including fluvial, eolian, and gully erosion;

Soil nutrients and toxics status;

Nutrient and toxic inputs including agricultural and all forms of irrigation and drainage management;

Riparian corridor and habitat status;

Source/sink for trace gases, especially CO_2;

Atmospheric trace gas composition (including NO_x, hydrocarbons, and ozone);

System biomass;

Optimized distribution of monitoring and intensive (index) sites;

Management practice change, surveyed regularly (social and economic drivers including regulations and farming practices).

Variables to measure these parameters are listed in the following table.

TABLE 7. VARIABLES TO MEASURE FOR RANGELANDS/CROPLANDS

Parameter	Variables to measure
þ Primary Production/ biomass	Spatial and temporal patterns (need research on remote sensing and ground validation techniques)
þ Soil quality/fertility	Nutrients, salinity, pH, minerals, nitrogen, phosphate
þ Biodiversity	Abundance, richness, invasives, exotics, pests, diseases
þ Climate	Physical, chemical
þ Hydrology	Surface and ground water quality; spatial and temporal variability
þ Land cover/pattern/ change	Landscape metrics; intensity of management practices; landscape patterns

Freshwater Ecosystems

The group worked to define the science questions that need to be answered and the key parameters that need to be measured to address the goods and services associated with the following categories: hydrology; chemistry/biology; water quantity; productivity of commercially valued species; ecosystem diversity; and biodiversity. The questions identified during this session were as follows:

Water Quality and Human Health Questions:

- þ Is the water safe to drink?
- þ What are the processes of transport, storage, and transformation of pollutants and nutrients affecting water quality?
- þ How will natural and anthropogenic stresses effect processes and modify water quality trends?
- þ What are the most important (practical and focused) chemicals to measure?

Water Quantity Questions:

- þ How much water is there? What are the trends in water quantity?
- þ Where is the water (including ground water)?
- þ What are the water levels at different times of year?
- þ How does water quantity interact with land use?
- þ How is water quantity affected by anthropogenic influences?
- þ Is there enough water for drinking, recreation, commercial use, and sustainable ecosystems?

Productivity of Commercially-Valued Species Questions:

- þ Are the fish safe to eat?
- þ What are population trends, causes of decline, and mechanisms of restoration?
- þ In which species and toxins is there bioaccumulation?
- þ In which species and toxins is there biomagnification?

Ecosystem Diversity Questions:

- þ What are the risks when species, communities, or habitats become endangered or extinct?
- þ What species, communities, or habitats are endangered or extinct and why?

- þ Does loss of species degrade the ecosystem?
- þ If other species are declining, how will humans be affected? Or, phrased another way, is species loss an indicator of change in the human population?
- þ What invasive species are present? Where are they? How can, or should, we mitigate them?

Biogeochemical Flux Questions:

- þ Are agricultural applications affecting water supplies?
- þ What are the trends of nutrient and pollutant fluxes to estuaries?
- þ Are pesticides contaminating groundwater? Where? How rapidly? How long do pesticides persist in groundwater?
- þ What has the Clean Air Act done to reduce acidification and introduction of metals to surface water?

Biodiversity Questions:

- þ Should we choose some key species to address biodiversity?

These questions were then used to identify key parameters to be measured as shown in the following table:

Category	Valued Good/Service	Necessary Monitoring Parameters	Comments
Water Quality	þ Drinking Water/ Human Health þ Species and Ecological Health/ Sustainability þ Recreation þ Commercial Uses	major ions, plant nutrients, water clarity, algal biomass, oxygen stress, dissolved organic compounds, pH, ANC, metals, salinity, VOCs, pesticides, pathogens, fecal coliforms, temperature	must also monitor driving forces for change: climate, human demographics, land use, industrial, urban, and agricultural outputs to land, air, and water
Water Quantity	þ Human Health þ Agricultural Needs þ Species and Ecological Health/ Sustainability þ Recreation þ Commercial Uses (incl. navigability) þ Flood Control	flow rates, water levels, sediment (suspended and bed-velocity), residence time, size of hydrologic system (surface and ground water, precipitation, connectivity, wetlands, disturbance frequency/intensity	must also monitor driving forces for change: climate, human demographics, land use, industrial, urban, and agricultural outputs to land, air, and water
Productivity of Commercially-Valued Species	þ Human Health þ Human and other Species' Food Supply þ Species and Ecological Health/ Sustainability þ Biodiversity þ Recreation þ Gauge for Assessing Benefit of Management Actions	organism health, tissue concentrations of pollutants, rates of bioaccumulation, magnification, tumors, lesions, pathogens, endocrine disruptors, abnormalities, recruitment, harvest rates, trophic health, food supplies, food web status, habitat structure and status, area of suitable habitat, water qualilty, quantity, temperature, habitat characteristics, UV, degree of alteration	must also monitor driving forces for change: climate, human demographics, land use, industrial, urban, and agricultural outputs to land, air, and water
Ecosystem Diversity	þ Natural System Functions þ Genetic and Species Diversity þ Natural Products þ Gauge for Assessing Benefit of Political/Managerial Actions	species lists (population and taxa), indicator species, ecological processes (NPP, biomass, turnover rates), geomorphological characteristics (areas that are protected, impounded, flood plain, riparian, wetlands, developed, connectivity)	must also monitor driving forces for change: climate, human demographics, land use, industrial, urban, and agricultural outputs to land, air, and water
Biogeochemical fluxes	þ Natural System Functions and Productivity þ Human Health þ Ecosystem Sustainability þ Food Supply þ Gauge for Assessing the Benefit of Political/Managerial Actions	ecological processes (NPP, biomass, turnover rates, major nutrients and ions, pH, ANC, metals, salinity, natural disturbance rates and intensity, human-caused disturbance rates and intensity	must also monitor driving forces for change: climate, human demographics, land use, industrial, urban, and agricultural outputs to land, air, and water

Coastal/Marine Ecosystems

The group listed those minimum variables/parameters viewed as necessary to measure the capability of coastal and marine ecosystems to provide valued goods and services.

Category	**Valued Good/Service**	**Necessary Monitoring Parameters**	**Comments**
Pollutant/pathogen detoxification, dilution, and storage (split from "Biogeochemical Functions")	þ Carbon storage þ Nutrient cycling þ Depuration and assimilation	þ Biological oxygen demand þ Sediment oxygen demand þ Sedimentation/ sediment budget þ Assimilative capacity	Pollutants = stressors, not goods/services
Biogeochemical Functions	þ Biogenic mineral production þ Accretion	þ Standing crop of primary producers/ biomass þ Wetland soil accretion/ loss þ Soil/benthic sediment carbon stock	Pollutants may fit here if they affect biogeochemical functions
Hydrological Functions	þ Flood control þ Tidal exchange þ Sediment retention	þ Water level/tidal height þ Wetlands area/ distribution (coastal floodplains) þ Salinity distribution/ variability þ temperature distribution þ Oxygen, total carbon þ Fresh groundwater levels	"Boundaries" of coastal/marine ecosystem may vary by parameter—consistency not necessary
Geomorphologic Functions	þ Navigable waters, ports, shipping þ Wind, wave buffeting	þ Bathymetry þ Erosion/accretion	

Ecosystem Diversity	þ Genetics and species diversity (gene bank) þ Natural products, pharmaceuticals þ Habitat diversity	þ Keystone/indicator species þ Benthic substrate þ Habitat maps (including stock assessments, types, sizes, ages; pelagic/ benthic/planktonic) þ Genetic diversity of populations (gene pools)	Habitats need to be mapped in conjunction with sediments and substrates as well as in relation to human-induced disturbances. Habitats are getting less diverse due to anthropogenic activities (sedimentation, fishing).
Aesthetics and Existence Values	þ Space for living and recreation þ Charismatic species þ Tourism þ Environmental quality þ Cultural/spiritual/ heritage	þ Land cover/use characteristics þ Trash/floatables þ Water quality (gross) þ Beach access þ Demographics	Need to measure socio-economic parameters such as tourist-days and dollars.
Atmospheric and Climatological Function	þ Deposition þ Air quality	þ Criteria pollutants and deposition þ Air toxics and trace gases þ Meteorology (including rain) þ Visibility	

Measurements for each category are listed in the following table:

General Parameter	**Measures**	**Comments**
Human activity within the coastal zone	þ Fishing pressure þ Transportation þ Construction/infrastructure þ Population/urbanization þ Dredging/filling þ Groundwater draw-down þ Mineral extraction þ Recreation þ Demographics	

General Parameter	Measures	Comments
Geomorphology	þ Shoreline (topography) þ Bathymetry þ Erosion/accretion þ Benthic mapping (sediment type/diversity, fragmentation) þ Tides and sea level þ Temperature, salinity, wind, water level	Currents may be measured at key points, but circulation studies will require models, which require a lot of data.
Productivity of economically valued species (not just commercial)	þ Stock assessments þ Yield/harvest þ Contaminant body burden þ Pathology þ Area/volume devoted to aquaculture	Merge the Table 1 lists of goods/ services for commercially valued with aesthetics. Debate over categorization of "commercially valued species productivity" and non-commercial values like aesthetics.
Biogeochemical Transformations	þ Assimilation þ Productivity þ Nutrient cycling þ Decomposition/storage þ Sediment input/ sedimentation þ Carbon, oxygen, nitrogen, sulfate, organics	
Diversity	þ Coastal benthic, pelagic, and planktonic community structure þ Keystone/indicator species	Keystone species implies a function within the system. Most parameters already measured routinely, but not consistently or interoperably. Need to prepare detailed inventories of existing monitoring data.
Aesthetics and Existence Values	þ Land use/tourism (beach use, living space) þ Trash/floatables on the beach þ Environmental quality/ water quality þ Beach access	Keep aesthetics separate from human activities. Demographics moved to Human Activity function.
Atmospheric and Climatological Function		An atmospheric function was to be prepared for the workshop as a whole; not specific to coastal/marine; may be useful to other groups as well.

4. SYNTHESIS TALKS

Ecosystem Health: Challenges in Synthesis and Prediction

The panel on "Ecosystem Health: Challenges in Synthesis and Prediction" consisted of four senior federal scientists and four senior scientists from outside the government. Each is experienced in both performing and managing environmental synthesis work. The panel members were asked to provide their perspectives on the challenges inherent in synthesis and prediction.

Dr. Catherine Woteki
Acting Undersecretary for Research, Education, and Economics
U.S. Department of Agriculture

Dr. Woteki's career has focused predominantly on human health monitoring, most recently through the National Nutrition Monitoring System. Because human health and ecosystem monitoring have much in common, she offered the following ten observations on the challenges facing the environmental monitoring initiative:

(1) The first challenge is monitoring itself. Most federal monitoring programs are required to provide specific information for policy, program, or regulatory purposes. Issues fall within three “domains”—the monitoring/surveys/systems domain; the public policy domain; and the research domain. Policy defines the scope and types of information needed, and results, in turn, help refine policy. Monitoring also provides hypotheses to be tested by research, thus forming a closed loop.

(2) The second challenge: modeling and synthesis compete with data collection for resources and attention. Historically, funding for data collection has greatly exceeded that for synthesis.

(3) The research community must be involved in analysis of the monitoring data, which requires that data and data specifications (meta-data) be disseminated in a timely and well-documented manner. Data originators and users must recognize each other's needs. Policies on data release and data confidentiality also need to be developed.

(4) Monitoring data and resulting analyses must be scientifically and legally credible. This requires rigorous quality assurance and quality control. The data must also be comparable through time.

(5) Monitoring methods tend to lag behind the state of the art, which has significant implications for long time-trend analyses.

(6) States and local governments will want comparable data to answer their own policy questions, and are likely to increase pressure for technical assistance and

exportable technologies to be able to build on federal programs.

(7) The baseline is critical for long-term assessment of trends. How the baseline is reported is also very important for the overall credibility of the program and its results.

(8) There needs to be genuine commitment at all levels to overcoming significant institutional barriers, both within and among key institutions, as well as among scientists (territoriality).

(9) The credibility of the “National Report Card” will be based on who does the analysis. A well respected national nutrition report card that is produced by an expert panel of members of the Federation of American Societies for Experimental Biology represents one successful model,

(10) The “National Environmental Report Card” is a good idea, but we may not be able to assign “grades” to environmental values. Instead, the report card could categorize issues of concern, issues not of concern, and issues where insufficient information or understanding exist. USDA has found this approach to be useful for human nutrition.

Dr. Robert Huggett
Assistant Administrator for Research and Development
U.S. Environmental Protection Agency

Dr. Huggett touched upon a variety of practical considerations that need to be taken account of in the effort to integrate and synthesize based on existing programs for environmental monitoring. First, it is currently common practice **not** to analyze dependent and independent variables concurrently, either in time or place. While programs frequently monitor the physical characteristics of an environment (e.g., water quality parameters), it is rare to investigate the health of its biological components at the same time, particularly because measurements are not typically made in support of environmental assessments, but rather to ensure regulatory compliance. The assumption that compliance with the law means that the environment is healthy is, however, usually unwarranted. Second, many monitoring data are of limited usefulness because they are collected to test only a narrow hypothesis or no hypothesis at all.

Monitoring programs designed years ago may also no longer be appropriate for current needs in terms of spatial or temporal variability. The need to make measurements at twice the frequency of the events being monitored (the "Nyquist

Frequency") should be recognized. The best techniques (usually based on the most recent methods) are often not used for fear of breaking a long chain of monitoring data. Resource constraints in both government and academia can also make data collection efforts more difficult, but this can be minimized through collaboration.

The production of a credible "report card" that is not overly simplistic will be made difficult by the fact that science really doesn't know much about the environment. Clearly, more research is needed to understand effects at higher levels of biological organization. But perhaps the most serious challenge to credible analyses stems from the fact that the designers of monitoring programs are often not available to, or capable of, conducting the necessary synthesis. The total program should be designed up front, with the experts involved in all stages - design, data collection, and synthesis. And the necessary long-term support needs to be assured. To have a "report card" in five years, funds must be committed now, and there is no time to waste. Annual budget arguments and fluctuations must be avoided. The Vice President wants to know if the environment is getting better or worse, and is asking for accountability from a $500 million annual federal program. Since this seemingly simple question cannot now be answered, we must get started immediately to evaluate our existing monitoring systems and make a start on answering the question.

Dr. Bonnie McGregor
Associate Director, U.S. Geological Survey

Dr. McGregor addressed aspects of data and information management: including data characteristics, standards, quality, integration and interoperability.

Data have temporal (rate of change), spatial, and frequency characteristics that need to be considered, framing questions and issues from an understanding of the system that's being monitored in order to be effective. The challenge is to design a monitoring system with the range to accommodate both averages and extremes. For example, coastal land loss in Louisiana averages 9 meters per year; but Hurricane Andrew caused a loss of 30 meters in one event! Similarly, temporal variability—whether in minutes or years— must be an inherent design characteristic. Spatial aspects and variability control the number and locations of monitoring sites. However, monitoring temporal and spatial aspects will allow an understanding of processes only if natural variability can be determined. Net change can be determined only if instruments have adequate resolution. For example, modeling water flow in South Florida is very challenging, given the centimeter-scale resolution needed to model flow in a very flat terrain.

Data standards are also critical. Although adequate metadata standards already exist, they need to be used more effectively. The National Spatial Data Infrastructure, mandated by Executive Order 12906, directs the implementation of meta-data by all federal programs and mandates standards, partnerships, and other critical elements for data management. The National Spatial Data Clearinghouse brings together data sets and serves as a pointer to federal data repositories. It is also necessary to know what analyses (i.e., laboratory or analytical techniques) have been used to generate the data, the data's comparability, and its original purpose. The Federal Geographic Data Committee, which Secretary Babbitt chairs, serves as a high-level forum for agencies and states to discuss these issues. We know that federal, state, and non-governmental organizations can work together successfully. The Strategy for Improving Water-Quality Monitoring in the United States, a publication of the Intergovernmental Task Force on Monitoring Water Quality (ITFM), is a good example of how the process can work.

Quality assurance for data is critical, particularly for understanding data comparability. Integration and interoperability are a challenge, and "stacking" layers of data is not enough. Integrating data from multiple disciplines will be the key. The underlying parameters of the data are necessary to understand causality. An interagency team that looked at the 1993 floods on the Mississippi River— and subsequent levee failures— as a model for analyzing the meaning of data in context can serve as a useful model. Digital data and geographic information systems (GIS) are tools that allow understanding of causality, but one needs more than landscape data to understand water quality. Also needed are coordinated information on the biology, surface and subsurface geology, land use, and many other elements. Programs such as the Mid Atlantic Pilot have valuable lessons to offer and make a good starting point. What is working well? What is behind successful coordination? If the goal is to understand national and global environmental changes, one must relate trends to cause. One needs to predict, model, and integrate.

In summary, the mandatory components of a national monitoring data program are: data; a clearinghouse; data management; data comparability; data coordination; and the use of existing pilot studies to learn how to improve linkages among networks.

Dr. Robert Harriss
Chief Scientist, Mission to Planet Earth
National Aeronautics and Space Administration

Dr. Harriss used the example of the Earth Observing System (EOS) to illustrate some recommendations for a national strategy for environmental monitoring. The original EOS was universally attacked as unresponsive to scientific needs, cumbersome and expensive. NASA's leadership responded with a complete redesign, drawing on lessons learned as well as state-of-the-art technology. They recognized that revolutionary change does not seek marginal improvement, but rather returns to fundamental principles. The redesign of EOS was based on an important NASA core principle: maintaining the necessary measurements while allowing for technology diffusion. The move to small, cheap satellites produced the same measurements at half the cost and still provides greater scientific responsiveness.

A national strategy for environmental monitoring is quite different from a design or plan for monitoring. A strategy can provide a forum for all stakeholders, from end users to component providers, to participate early, and can help to balance support among an array of long-term and short-term activities. Most importantly, a strategy can be used to define its core principles. While core principles were implied in much of the workshop discussion, they had not been explicitly articulated. Dr. Harriss was consequently concerned that key concepts, such as a commitment to continuous technology innovation and diffusion, had not been addressed. Formulating the needed strategy would provide an opportunity to ensure that the link between core research and a technology program is made. He offered several more examples of what he believes are "core principles":

þ There is a need for integrated, rather than isolated, observations to understand environmental systems. The monitoring now in place was designed in an era when single-discipline science was common.

þ Protocols, measurements, and meta-data must be documented and published. The documentation can serve as a “filter” for selecting appropriate monitoring sites and data sets.

þ Regular scientific assessments of the state of understanding must be part of the design. He suggested that the embedded evaluations in the Stratospheric Ozone Program represent a successful model for this.

þ Metrics, which already exist for stressors, must also be developed for efficient characterization of inputs. Better metrics will engage a broader segment of the public, because they document programmatic efficiencies. Examples abound, and this in turn will lead towards improved sustainability.

Dr. Harriss believes that if one used such core principles to screen existing monitoring programs, half would not meet criteria and would be eliminated. He urged that programs that have outlived their usefulness or defensibility be weeded out, which may be initially costly, but would produce significant long-term benefits. He concluded by predicting that a transition to automated, self-calibrating technologies will be made within a decade. These will be easier to integrate, and will provide data that will be distributed, very purposeful, and “federated” into flexible national systems to meet regional needs at various scales. He also predicted that cheaper, space-based systems using pattern recognition techniques will replace current expensive hardware, at only $200-300 million per year. He urged that the government support a “skunk works” of creative applied research in parallel with implementing the national monitoring system. Finally, he encouraged social scientists and economists to be involved as well as natural scientists.

Professor William Clark
Sidney Harmon Professor of International Science, Public Policy, and Human Development
John F. Kennedy School of Government, Harvard University

Dr. Clark offered three observations:

(1) The “National Environmental Report Card” is a good idea. He suggested that environmental scientists and regulators have historically blundered in failing to document the benefits, as well as the costs (an investment amounting to 1.5 - 2 percent of the GNP, which is hundreds of times more than what is spent on environmental monitoring) associated with environmental regulations. The environmental community needs to account to the public for this investment, but has not done so, even though this accountability was inherent in the concept of the Council on Environmental Quality. We need to make it clear that remarkable improvements have occurred over the past 25 years, even though the public doesn't realize it. A good report card will provide information on what the public is getting for its investment in environmental regulations. Done properly, the “footnotes” to the report card should provide a compelling argument for continued Congressional support. Although economics, like environmental science, does not yet have all it needs, it does have the basics. Once the environmental sciences have their equivalent of the jobless rate, inflation rate, consumer price index, and Gross National Product, we can move on. Dr. Clark also pointed out that the United Nations Environment Program, the World Watch Institute, and other organizations already produce "report cards," all using minuscule staffs and data collected and interpreted by the very scientists who claim that not enough is known to do this. All these documents rely on the same monitoring data, yet the monitoring programs do not get credit. He urged that the first report card be done quickly and that credit be acknowledged, and gratefully accepted by the monitoring programs. Any criticism of the effort is likely to be less dangerous than failure to account for the trillions spent on environmental regulation.

(2) Monitoring activities should be kept separate from assessments. Dr. Clark noted that environmental protection is highly politicized, and invited the audience to

imagine the repercussions if groups like the Bureau of Labor Statistics, the Federal Reserve Board, or other independent purveyors of economic statistics insisted on publishing their own analyses, interpretations, and opinions instead of just reporting the data. They would all be abolished very quickly! Economic statistics have respect and credibility precisely because the institutions responsible for them have avoided confusing the collection and publication of quality data with producing the politically charged assessments that are drawn from them. The non-partisan, non-judgmental statistics they produce are protected from highly political interpretation. While data and analyses may indeed be reported by the same *people*, they must be separated institutionally or be undermined by political attacks.

(3) The monitoring organization should not be entirely federal. Although conventional wisdom says that only the federal government has the resources, influence, and capability to organize a national environmental monitoring and research program, this isn't necessarily so. And there is already significant interest in the private sector, whose worst enemy is not the environmental community, but rather bad data, in having good, long-term data. It is in the best interests of the private sector to have monitoring that is not tied to political whim or administrations that come and go. The President's Council on Sustainable Development has successfully set the stage for significant involvement of the private sector in such endeavors. Business needs to be involved in the national environmental monitoring program, as well. Not much emphasis, however, had been given to identifying alternative ways to organize and manage the monitoring program during the workshop. The real issue underlying leadership and organization of the program is the need for stability and continuity over a scale of decades. We need, therefore, to detach long-term planning and monitoring from the short-term (annual) attention of politics and federal appropriations. We need a “damper” to impose the consistency that Washington claims to want, but cannot provide.

Professor Jerry Franklin
Professor of Ecosystem Science
University of Washington

Dr. Franklin noted that he brings his experience in forming the NSF Long-Term Ecological Monitoring and Research Program (LTER), which he characterized as having “herded mules,” to the workshop. He is currently assisting the Chilean government to develop a major monitoring program for Tierra del Fuego. This will encompass over a million acres, and has goals in forestry development, sustainability, biodiversity, and many of the same issues confronting the United States. His answer to the “How does one do synthesis?” is to use regional teams involving federal, state, tribal, and academic partners. He pointed to the Forest Ecosystem Teams as a good model, and emphasized the need to conduct periodic assessments of performance and progress. He believes that the White House can foster interagency cooperation, as it did in the Pacific Northwest Assessment. In that case, BLM, FWS, USFS, and NMFS all worked together in response to an Executive Order. In the case of the national monitoring program, there is also a need to involve states and Native American Tribes. Strong leadership from above will be critical. Institutional and personal territoriality exist, and incentives as well as clout may be necessary.

His opinion was that the workshop had been overly concentrated on compiling lists of needs, parameters, functions, sites, and criteria. He believed that we are beyond contributing anything new at these conferences to such lists, and we should instead deal with the "realities" of designing operational monitoring systems, such as logistics and funding. He also noted that it is important to recognize that society, not science, provides many of the real environmental issues. For example, the spotted owl became significant not because it is a keystone species, but rather because it is socially desirable.

Clearly, we are not talking about designing a system from scratch. Building on existing programs is a necessity, and most monitoring will stay at the local level. Hundreds of millions of dollars will be spent, and reciprocal relationships need to be strengthened between levels of government. Much local monitoring is performed by non-specialists who have many other responsibilities, and consequently much is not done well. A national program must improve the quality and interoperability of this local monitoring, to make it meaningful at both the local and national levels. There is also a need for a critical analysis of existing data sets—to learn what we know and don't know; identify the meta data associated with these data sets, and sharpen our understanding of the entire inventory of existing data and programs.

The proposed network of intensive sites is a critical component of the national program.   They can contribute not only long-term data sets, but also large teams of interdisciplinary scientists. The program needs the capabilities and infrastructure offered by such sites. There are already 50 to 100 candidates, and though they may not be perfect, they are irreplaceable and cannot be duplicated. The National Parks should not be ruled out as possibilities —they can accommodate manipulation without harm. Major gaps in intensive-site systems should also be identified.

He offered six suggestions to the scientific community: (1) Limit, but don't throw out, your lists; get realistic in your monitoring values and parameters. (2) Provide strong leadership, horizontally (interagency) and vertically (national to local). There is not enough “vertical” attention. (3) Do some pilot assessments. There is value in such programs as South Florida, Pacific Northwest Forests, and Sierra Nevada, but more for planning purposes. It is imperative to conduct a national assessment before issuing a report card. Doing an assessment will firm perspectives on what is needed and what form the report card will take. The time and budget available for the assessment should be limited to counteract the tendency to always want more data. (4) Identify the major gaps in the intensive site networks. (5) Realize that a hierarchical monitoring system is not realistic. Monitoring networks require varying temporal and spatial scales. This is not amenable to a technological (remote-sensing) solution. A comprehensive monitoring program (particularly in the biological area) has many dimensions, and needs scientists on the ground. The Breeding Bird Survey is a classic example of a monitoring program that cannot be converted to a technology-driven effort. (6) Understand that funding is critical to monitoring at all levels. Long-term activities require assured funding, but federal agencies have not solved this problem. Some sort of trust fund, such as the one pioneered by The Nature Conservancy, might be considered to help assure long-term funding.

Dr. Walter Reid
Vice President for Programs
World Resources Institute

Dr. Reid focused his remarks on the challenge of the assessment and “report card.” The WRI has been preparing a biannual global "report card" for over 10 years, synthesizing and reporting on a number of variables from 170 countries. Their global report card has been adopted and is jointly sponsored by the United Nations Environment Program, the United Nations Development Program, and the World Bank. WRI recognized that the necessary data for the report card already existed, but were not aggregated. When the United Nations saw the value of these assessments—much of the credited source material comes from the United Nations—the WRI project became a de facto UN report card. The project has had an added benefit - where data and reporting gaps exist (and they are numerous), they tend to attract the attention of national managers who do not want their countries to show up as inadequately understood. Hence, the gaps tend to be self-correcting.

The aggregation of parameters, as discussed and debated during the workshop, is useful if there is some way to weight the information. Greenhouse gases are an example of an aggregation with a scientific basis. Qualitative aggregation methods are equally effective. WRI and the UN have found that aggregated data are very useful to policy makers. He believes that scientists tend to be overly cautious with assessments, and urged the participants to accept aggregations for coarse relevance without worrying about simulation modeling. A key requirement, however, is to define a goal or target for the indicator. Mandated targets are fine if they exist (air quality or water quality standards, for example), but if they don't, scientists should not hesitate to create them. For example, the Netherlands developed good water quality goals through scientific insight rather than policy. He pointed out that over time, familiarity with consistently applied and explained indices will begin to affect policy: a “GNP rise of 3 percent” means something useful because economists have provided guidance in interpreting a single value in terms of its underlying meaning. In fact, the report card is a bridge to economics. While it would be good to have a “Green GNP” that factors in resource depletion —this would certainly attract the attention of policy makers—it would be even better to embed environmental indicators into the economics.

Finally, he concluded by noting that there must be incentives for data providers. These incentives may be funding, but credit is also important. A national environmental report card, properly done, will create a demand among politicians for data needed to develop it; it will become a resource generator. Over-planning is not necessary — just begin the program, and the resources will come in parallel.

Dr. Berrien Moore
Director, Institute for the Study of Earth, Oceans, and Space
University of New Hampshire

Dr. Moore pointed out that, if it were not for the carbon dioxide data record collected at Mauna Loa, or the census data collected for two centuries, or for numerous similar instances of long-term data collection, very few inferences of cause and effect could be supported scientifically. For this reason, there is universal recognition of the value of monitoring. Simply knowing that the environment is changing at the global, national, and regional levels means we must have some useful data already. The environment will continue to change, and there is much value in using existing, established networks to take advantage of their data records. The first step is to make sense of these existing systems; they can only improve. Technology is improving, and in situ monitoring will undoubtedly also be enhanced. The key questions are “what to measure?”, “when to measure?”, “how to measure?”, and “how long to measure?”—the only simple answer is to the last question: forever, or until an issue no longer exists.

The biggest problem is not scientific, but political or institutional. Scientists should take credit for their programs, and make the policy makers more aware of where their facts are coming from. This is not a one-time thing; rather, we need to stay at it and build a sustainable system. Data have two key uses: *a priori*, where the existence of the data will create a value for it; and where data are needed to drive the explosion of mathematical simulation models now commonly used to assess biological, physical, and chemical systems. The federal government has done very well in supporting data collection; the problem is to take the next step and apply the data to real problems.

5. NEXT STEPS

Action Items Recommended by the Workshop

At the conclusion of the workshop participants reached a consensus on the following recommendations:

(1) Complete, within 18 months, a first draft National Assessment that will--

- þ Iterate to the 2001 Report Card
- þ Require evaluation of existing monitoring and research;

(2) Initiate a series of regional pilots, starting with the Mid Atlantic, that take monitoring and assessment to a more detailed level and address institutional issues;

(3) Evaluate the current capabilities for providing a pilot concept of index sites, considering --

- þ What intensively monitored sites we now have,
- þ What will be their roles in the overall effort (e.g. cause and effect),
- þ What else would be needed to make the index sites concept reality,
- þ How to implement the pilot index sites within their prescribed roles, with built-in evaluations of performance.

These recommendations have been presented to, and accepted by, the CENR Steering Committee for Environmental Monitoring which is directing implementation actions.

Report Card

The concept of a report card permeated the workshop and provided a distinct focus for discussion. The workshop's goal, however, was not to fill out the report card but to start designing one. Specifically, the workshop aimed to develop recommendations for the design of an ecosystem health report card and the monitoring systems needed to fill it out. Dr. Gibbons noted in his opening remarks that success in producing such a report depends upon the “collective wisdom” of the scientific community and that it was the responsibility of the workshop participants to define the challenges and opportunities of engaging in this endeavor.

Worksop participants recommended that there be a commitment to developing a national assessment and draft report card within 18-24 months. At least one iteration was envisioned before public release. This would provide the impetus to draw in other stakeholders. Endorsement from the CENR Steering Committee will lead to the potential for in-kind commitments from states, NGOs, and the private sector.

Some participants supported the report card, but suggested that five years may be a luxury. Once the effort is initiated, the public may demand to know the state of the environment within three years or less. Part of the assignment—understanding gaps and existing programs—may already be done. A team has looked at national datasets in detail for their potential value for environmental indicators (as part of EPA's National Environmental Performance Partnerships), and found that existing data are inadequate. The group was urged not to overlook such work and to utilize information clearinghouses already available.

In the course of the workshop a number of basic observations were made about what the report card should and should not be. A report card should:

þ be a synthesis at a very high level;
þ be one step, perhaps the last step of an assessment, not the first;
þ express uncertainty;
þ be regional -- avoid mixing apples and oranges or applying the same notions of status to the Great Lakes as to desert areas, for example;
þ use a simplified way of describing the status and trends of ecosystems relative to some goals or standards, rather than as "grades";
þ combine numerous parameters into various aggregations or "indices" that would be useful to the public;
þ include biological parameters as well as physical and chemical;
þ be iterative and play a role in a long-term process
þ focus on status and trends initially, but evolve to consider causeand effect and, eventually, include a forecast component
þ not be allowed to create pressure to overly simplify the monitoring and assessment programs on which it rests.

Other characteristics of the report card were discussed without reaching a consensus. For instance, consideration was given to whether the report card and the monitoring system on which it is based should be primarily focused on ecosystems or the broader environment. The degree to which socio-economic interests and experts need to be involved was discussed. The "value" of status and trends as lines of the report card was felt to be difficult to evaluate without explicitly defined policy goals. One of the issues grappled with was whether the report card should be consistent in reporting "up" and "down" trends consistently as good or bad. The only values on which there was agreement were related to mandates such as air and water quality or where "more is better", as in timber production.

Report Card Categories

Parameters to include on the report card should be closely related to valued goods and services. The following seven factors might characterize an "important" parameter to include in an "environmental report card":

- þ Sustainability
- þ Ease with which trends could be detected
- þ Integrative—an indicator of other values as well
- þ Primary characteristic of ecosystems and processes
- þ Regional importance
- þ Commercial value
- þ Relevance to public

The Coastal/Marine group came closest to being able to define a list of report card "subjects". Their list comprised the following items:

- þ Eutrophic states
  - — Chlorophyll-a
  - — Nutrients
  - — Dissolved oxygen
  - — Water clarity
- þ Level of contamination
- þ Harvestable production
- þ Recreational index
- þ Habitat index
- þ Diversity and community structure
- þ Air quality

The Rangeland/Cropland group selected the following six topics for the report card. All six high-priority parameters would be needed both for status and trends and cause and effects.

Primary Production/biomass

Soil quality/fertility
Biodiversity
Climate
Hydrology
Land cover/pattern/change

The Forest group used the following categories which might be items on a report card:

Timber production
Other commercially valued species
Status of natural pests and fire
Hunting of game animals
Biochemical functions
Hydrological functions
Atmospheric functions
Geomorphological functions
Ecosystem diversity
Aesthetic/existence values
Cross-cutting issues

The Freshwater group identified the seven categories shown in Table 8 for the report card.

Table 8. Parameters for Tracking Status and Trends in Freshwater Ecosystems

Parameter	**Comments**
Hydrologic Cycle	flow/level; sediment (suspended and bed-velocity); residence time; size of system (surface and groundwater); groundwater recharge; saline intrusion; long-term trends inflow; connectivity (networks, subsurface, wetland); wetland flow alteration
Habitat and Ecological Health	food web status (stream, lake, wetland, riparian); species lists; zooplankton size; groups (phytoplankton, macrophytes); other indicator groups; trophic level; ecological processes (NPP, decomposition); population assessments; pigments; organismal health; immunological, histological, bioassay; tumors, lesions, abnormalities; pathogens (coliform and others); Ultraviolet rays; endocrine disruptors; habitat structure and development; riparian/floodplain/wetland characteristics; structure of streams, lakes, wetlands; fragmentation and connectivity
Human Health	fish edibility (tissue concentrations); swimmability; drinkability; highest desired use of an ecosystem; agricultural/industrial use; water volume
Climate	precipitation; temperature; evaporation and transpiration; wind speed and direction; snowpack; soil moisture and temperature; deposition (flux and concentration); greenhouse gas release
Human Demographics	transportation; waste-water loading; shifting demographics/culture/ recreation; shoreline development; water use and pumping rates; water biology harvesting (fish, ducks); highest desired use; development in high risk areas; reservoirs (lifetime, filling rate, effect on ecosystem)
Basin Characteristics	geomorphology/lithology; longitudinal location; basin hazards/ disturbance history; river form (area protected, area of impounded waters, flood plain/riparian/wetland areas); drainage network/connectivity; educational facilities
Water Quality	major ions; plant nutrients; water clarity; algal biomass; oxygen stress; dissolved organic/inorganic content, speciation; pH, ANC, AI; nutrient bioassays; salinity; volatile organic compounds; pesticides; pathogens; fecal coliform; wetlands as filters; wetland flux alterations

The group noted that parameters have many dimensions. Water quality, for instance, includes:

þ Drinking water
þ Recreational use
þ Lakes

- þ Streams
- þ Wetlands
- þ Aesthetics

A possible report card item on drinking water, for instance, might be:

Drinking Water Report Card	**Measures**
Drinking Water Quality	þ Percent treated/untreated in groundwater, surface water, and cisterns þ Waterborne disease incidents þ National Drinking Water Standards achieved
Drinking Water Quantity	þ Percent time water supply not sufficient for demand

Similarly, it was suggested that the “streams” value could be measured by an index of hydrologic alterations, miles of wild-and-scenic river; biological diversity; and an water quality index.

Some participants felt that if the report card or the regional pilots are based upon the present structure, they will not succeed. Concern was expressed that the Framework was inadequate in its treatment of biological populations, which represented much less than one percent of the existing monitoring effort.

Completing a Report Card Prototype

Jerry Melillo proposed to lay out a five year plan to move forward simultaneously with the best possible national report card and a fleshed-out vision of a national monitoring network involving regional and states' needs. He envisioned pilot surveys and partnerships with states, noting that there should not be a choice between them.

The report card effort needs to stress the positive aspects of environmental assessment, rather than be bogged down with information gaps. The Intergovernmental Panel on Climate Change’s approach to assessment was cited as a good example of how to state what is known, not known, and merely believed. It was also suggested that the White House re-emphasize the importance of the Executive Order mandating data standardization, as referred to by Bonnie McGregor in her panel presentation.

A national environmental report card, properly done, will create a demand from the public and decision-makers for data needed to develop it; it will become a resource generator. It was noted that States have similar needs and that they should be integrated into the national monitoring and assessment program. Monitoring data must be relevant to policy and management decisions, in order to ensure support for the needed monitoring efforts. Walter Reid, Vice President of World Resources Institute, cautioned against over-planning—just begin the program, and resources will come in parallel.

Emphasis was given to the point that the report card be consistent with and not at the expense of the national monitoring program. Although the quality of current programs needs to be examined, the group cautioned against dropping existing programs that are already reporting report-card parameters. The report card should be consistent with regional needs demonstrated through a regional pilot project. Careful thought should go into the report card design to ensure this. A regional pilot or pilots should be viewed as a necessary component of the overall effort. The report card's data collection imperative should not divert resources from the pilot or pilots.

Mid-Atlantic Pilot Project

The workshop participants agreed to recommend to CENR as a second action item that regional pilots be established around the country. Energy and resources should be committed to the Mid-Atlantic Regional Pilot Project at a minimum, and expand from there.

Dr. Donald Boesch, President of the University of Maryland's Center for Environmental and Estuarine Studies and leader of the Mid-Atlantic Regional Environmental Monitoring Workshop held by CENR in April of 1996, had presented the results of that meeting to this workshop. The Mid-Atlantic region is an excellent candidate to demonstrate the necessary relationship between a national "report card" and usefulness of monitoring information to regional and local decision-makers. The regional workshop had recommended that a central aspect of a pilot project be assessments which link monitoring and research to address regionally important environmental management issues. This will require more attention to linkages with the users of monitoring information including: responsiveness to decision-makers' information needs, interpretation of results, integration of environmental and resource data with social and economic considerations in assessments, dissemination of information to decision-makers and the public, and anticipatory prediction.

It was acknowledged that, in any regional area, a number of institutional barriers (real or imagined) must be overcome, and that aggressive efforts needed to be made to involve states, industry, NGOs, and Native Americans. Efforts to integrate cause and effect investigations and basic research into status-and-trends monitoring should be a vital component of these regional pilots. Participants urged that the regional pilots explore how to define regional boundaries more creatively than simple geographic or political demarcations.

In addition, special outreach efforts were suggested as necessary elements of the regional pilots. These may include additional conferences or workshops, but emphasis should be on implementation, not planning or endorsement. The participants cautioned that gaining consensus on the details of implementing the assessments will prove much more difficult than obtaining agreement to proceed. Regional pilot projects should further evaluate the present monitoring programs. It was suggested that such a programmatic evaluation should be done not just by scientists, but by a wide spectrum of users.

Some participants noted that there are many excellent state-led efforts to include in regional pilots and the national report card. A concern was expressed that no one seems to be responsible for organizing the many “ground troops” whose involvement will be necessary to implementing these action items. Dr. Melillo acknowledged that CENR and OSTP must set up a structure and provide support. However, he cautioned that the scientific leadership should come not from the White House but from the scientists.

A question was asked about an international component, noting that a national series of regional pilots will at least involve Canada, Mexico, and Russia, while the European communities have many comparable monitoring programs in place that we can learn from. Arguments were made to move more quickly to the regional pilots. Some perceived that federal agencies were making environmental decisions quickly without multidisciplinary analyses or focused attention.

Some skepticism was expressed about the pace of the environmental monitoring improvements. A concern was expressed that there is no mechanism mitigating against the same old way of doing things. It was noted that the ecological monitoring and research community is lagging behind in adopting new technologies. Establishment of a small, independent, parallel activity was suggested to see how improvements could be made.

Index Sites

Index sites should help address the link between ecosystem health and valued goods and services. The cause-and-effect questions that index sites are intended to address represent the paramount criterion in the Framework. With the new report card, it was suggested that the Framework paradigm may have shifted from intensive collection in a few regional pilots to sparse collection in many locations.

Some participants felt that “index sites” should be distinguished from “intensive sites” -- sites where comprehensive, long-term monitoring was conducted. Some urged keeping the dual functions separate in order to test their concepts.

Some participants felt that the new idea of a national environmental report card has distracted attention from discussion of the role of intensive sites. It was acknowledged that there is no clear consensus on intensive sites, but examples such as Hubbard Brook show how intensive sites will augment the regional pilots in ways that may otherwise be overlooked. The debate over intensive sites may require a subsequent conference.

Dr. Huggett noted that EPA is piloting intensive sites in 10 National Parks, but claimed that these were not enough. They will augment the value obtained from LTER sites, and build from them, but he urged other federal agencies to cooperate.

Others commented that the Framework concept is unproven and argued that it is premature to move ahead with index sites without some demonstration of effectiveness. They recommended sticking with the regional pilots to test the Framework. Index sites' primary value is to tie together regional assessments. Restraint was urged in moving one component of the Framework ahead of the others. The Framework writing team had considered index sites carefully, and realized that there were too many unanswered questions, such as “Why?”. The location of the sites depends upon the questions that need answering. Concern was also expressed about the sensitivity of index sites -- too generic sites will impair their value. Monitoring will depend upon the landscape, and there is no single way to define an “index site”—it may even need to be a mosaic of sites. The purpose of index sites is to bring process level understanding to the regional levels where the resource management decisions are being made. The Framework writing team did not question the need for index sites, but some member felt that it is premature to institute them broadly now before additional testing and piloting is done. Others added that the idea of siting research sites within the monitoring network may not be good. Research sites need to remain flexible to respond to any research question that arises, and research should not be tied to particular geographic sites.

Each of the breakout groups had varying levels of discussion of the concept of Index Sites, and some of their considerations and suggestions are summarized as follows

þ Many present measurement sites are not intensive. Index sites should be formed at some current monitoring locations by co-locating presently scattered measurements.

- þ The term “site” may be too restrictive; intensive monitoring of populations across geographic ranges might be better as an “index”.

- þ An index site is not a monitoring site of probability-based parameters so much as it should be linked to the calibration and validation of cause and effect.

- þ Index sites should be linked to existing programs and sites, and must build on existing networks.

- þ Index sites will not be used to statistically represent the nation though they may be linked to a national probability-based network, and they need to link to existing monitoring programs and build on state, federal, and international models. A good example was cited as the Biosphere Reserves.

- þ There should be about 200 index sites nationally, each on the order of 100 km^2.

- þ A “core” would be intensively monitored experimental sites subject to extensive manipulation. These would be used for testing causality relationships.

- þ The core would be surrounded by larger “reserves” encompassing varied landforms and land-use patterns, similar to LTER sites.

- þ The site network should represent a range of large and small ecosystem types, and should share common protocols and procedures.

- þ Index sites should be located at places that allow intensive cause and effect studies to validate and anchor the national monitoring networks and resolve trends.

- þ Index sites could be viewed as “sampling centers”, or “index centers”, each with some specific responsibilities.

- þ Measurements would be driven by common parameters and by conceptual hypotheses specific to the site type, with drivers for research at the sites likely being policy questions.

- þ The “only absolute criterion” for index sites was that experimentation was critical to understanding cause and effect, and land use is an important component in that consideration.

þ Index sites help address the link between ecosystem health and valued goods and services.

þ Intensive sites should not be co-located with survey sites unless there are intrinsic reasons to do so.

þ There was concern that forcing co-location may result in moving a program from a good site to one less well-suited.

þ The cause and effect questions that index sites are intended to address represent the paramount criterion in the framework document.

þ Independent variables (chemical and physical measures) and dependent variables (biota) are not often collected together, and they should be.

þ There was caution against dropping existing programs that are already reporting report-card parameters.

þ Monitoring data that are relevant to policy and management decisions will provide a funding commitment to more monitoring.

þ The report-card paradigm may shift emphasis from intensive collection in a few regional pilots to sparse collection in many locations.

þ A number of criteria for selection of index sites were offered:

1. A range of human impacts, from heavy to pristine.
2. A range of size and geomorphic shape.
   - þ Whole ecosystems/watersheds are preferable to small parcels.
   - þ A range of relative scales between the size of systems being impacted and the size of the stressor (*i.e.*, in regional context).
3. Representative biogeographic provinces, including estuarine, coastal, and continental shelf
4. Areas where the probability of change is high.
5. Areas that can be related to multi-ecosystem (multi-media) studies (watershed, airshed)
6. “Operational” criteria
   - þ Access to scientific infrastructure and research

- þ Availability of historical data
- þ Accessibility/control commitments
- þ Multidisciplinary
- þ Long-term commitments

Workshop participants agreed that the issue of index sites should be put on CENR's agenda for discussion and clarification. This is not the same as recommending that index sites be established in any particular way. A few index sites should be established and used to refine the process. Participants supported the “pilot-testing” of the index sites, and pressed for the pilots to include a wide spectrum of index site types, noting that these pilots will enhance communications among scientists over the merits and value of these sites in the broadest possible context. It was also noted that they would offer ways to test the scaling of information from local and regional to national levels, which will be necessary for the report card. CENR should not wait until after the first report card to begin. Some felt that the pilots could begin without establishing new sites—adequate sites already exist, and what is needed are mechanisms to identify and coordinate data. Agreement was reached to recommend that CENR discuss index sites, with the understanding that the group was endorsing the concept's pilot-testing in a fiscally responsible manner.

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